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BD+20 1790 b: Chronicle of an exoplanetary discovery

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Abstract. In this contribution we report evidence for a planetary companion around a young and active late-type K star. Our group has been developing a study of stellar activity and kinematics for this star over the past years. Previous results show a high level of stellar activity, with the presence of prominence-like structures, spots on surface and strong flare events. Radial velocity (RV) variations with a semi-amplitude of up to 1 km s^{-1} were detected. When the nature of these variations were investigated it was found that they are not due to stellar activity. Based upon the analysis of bisector velocity span, as well as Ca II H & K emission, we report that the best explanation for RV variation is the presence of a sub-stellar companion. The Keplerian fit of the RV data yields an orbital solution for a close-in massive planet with an orbital period of 7.783 days. Also, the presence of this close-in massive planet chould be an interpretation for the high level of stellar activity detected.

Keywords: stars: activity — stars: late-type — stars: individual (BD+20 1790) — stars: planetary systems
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BD+20 1790: CHROMOSPHERIC AND PHOTOSPHERIC ACTIVITY

BD+20 1790 was classified by Jeffries [4] as a K5Ve star. López-Santiago [6] proposed its membership in the AB Dor moving group and derived an estimate age of 35–80Myr by comparing the equivalent width of Li λ 6708 Å with the spectral type.

In order to study the stellar activity, our group has been carried out a spectroscopic monitoring with high temporal and spectral resolution and two-band photometry. Strong chromospheric activity was detected in several observing runs, described by Hernán-Obispo [2], [3]. In spite of the fact that the rotational velocity of BD+20 1790 is not very high ($v\sin i \sim$10 km s^{-1}), all activity indicators are in emission, from Ca II H & K to Ca II IRT lines including all Balmer lines.

Through the study of profile line asymmetries of Hα and Hβ, prominence–like structures have been detected in the chromosphere of the star [2, 3]. In addition, strong

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flare events were observed (Fig. 1).

Photometric observations performed produced a light curve with evidence of rotational modulation, the amplitude of which is up to $\Delta V \sim 0.^m06$ and indicates the presence of spots on the surface (Fig.2) . The period analysis of the entire set of observations reveals a photometric period of 2.801($\pm$0.001) days, in agreement with the period given by SuperWASP photometric survey [8]. The different amplitude in each band (larger in the bluer g' band) is consistent with strong spotty surface features with strong temperature contrasts, and the g' amplitude suggests a surface spot coverage of 7% at least.
Heliocentric RV were determined using the cross-correlation technique. Variations of up to 1 km s^{-1} were observed; significantly larger than the individual measurement errors (0.10 to 0.20 km s^{-1}) or the systematic error (0.05 km s^{-1})

STELLAR ACTIVITY VS. PLANETARY COMPANION

The nature of RV variations for BD+20 1790 was investigated. To discriminate if the RV variations are due stellar activity (see [10]) or dynamical motion of a star– planet system, we used the relationship of bisectors of the cross–correlation (CCF) and RV (see [9], [7]). The CCF has been determined by using the same procedure as in the RV case. The lack of a correlation indicates that the RV variations are not due to variations in the asymmetry of the photospheric profile lines, so not due to stellar activity. To support these results we determined the variation of stellar activity indicators, especially those that are ascribed to the presence of plage-like structures on the chromosphere (Ca II H & K). The lack of a correlation confirms that the RV variations could be due to a planetary companion (see details in Hernán–Obispo et al. 2008a, submited). As proposed by Cuntz [1] and Lanza [5], stellar magnetic activity may be influenced and enhanced by the presence of a close-in giant planet, thus this could be an interpretation for the high level of stellar activity detected in BD+20 1790.
We used the Lomb-Scargle periodogram to initially identify the possible periodicities in RV data. The periodogram contains many spurious peaks due to the uneven sampling of the data. However, we identified a group of strong peaks with periods between 6 and 12 days, being the 7.78 days the stronger one, as possible candidates. To compute the False Alarm Probability (FAP), we combined all the observations from each night in a single RV measure. With this we were able to generate much more realistic random periodograms. Using 10000 randomized samples (random switching of the radial velocities) found that the FAP was still smaller than 0.1% as shown in Fig.4.
We computed the orbital solution for the RV data using a standard Keplerian fit. A first fit derives a close-in massive planet in a circular orbit with a rotational period of 7.783 days ($a = 0.068$ AU, $M_2 \sin i = 6.87 M_{jup}$, $e = 0.05$, $\chi^2 = 1.09$). Due to the observational strategy (high temporal resolution) the eccentricity is poorly constrained. Also, taking into account that the estimated time for circularization is about of several Gyr, we cannot discard the possibility of an eccentric orbit. A second fit for an eccentric orbit was computed ($a = 0.066$ AU, $M_2 \sin i = 5.44 M_{jup}$, $e = 0.25$, $\chi^2 = 0.83$). Both solutions are shown in Fig.3.

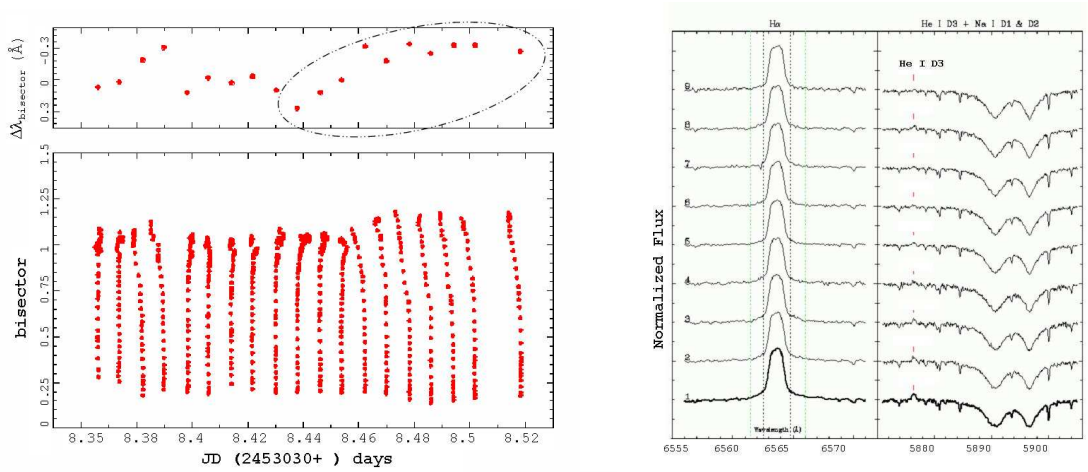

FIGURE 1. **Left**:Bisector of the subracted spectra of Hα line for the 02/02/2004. The dashed ellipse marks the prominence transit. Time of transit$\sim$ 2 h. **Right:** Sequence of consecutive Hα (left) and He I D_3 (right) line profile for the 22/11/04. We observed the gradual decay of the flare about $\sim$4h.

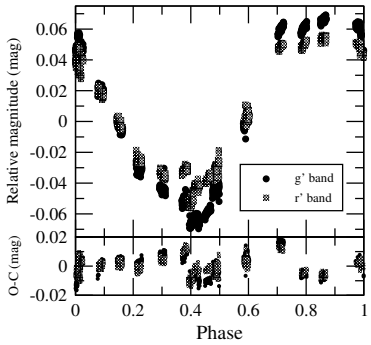

FIGURE 2. Photometry phased to the 2.801 days period. A linear trend and a zero point have been subtracted to both bands.

SUMMARY

This contribution reports the evidence of a planetary candidate orbiting around the young and active K5Ve star BD+20 1790. Based upon the analysis of bisector velocity span, as well as activity indicators, we report that the best explanation for RV variation is the presence of a sub-stellar companion. Since the RV data are not part of a planet search program, we can consider our results as a serendipitous evidence. Indeed, additional RV follow-up can allow us to constraint the orbital solution.

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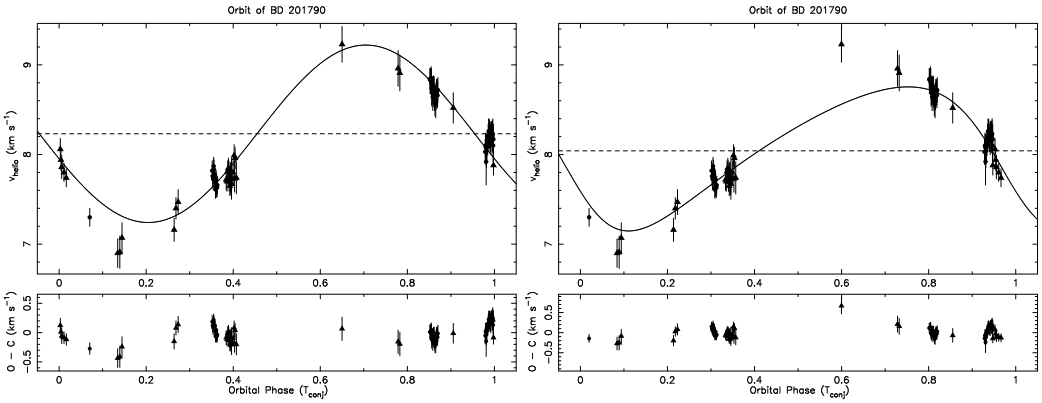

FIGURE 3. Radial velocity variability of BD+201790. **Left**: Orbital solution with eccentricity e=0.05. **Right**: Orbital solution with eccentricity e=0.25. Values marked with circle symbol represent SARG runs and triangle symbol FOCES runs.

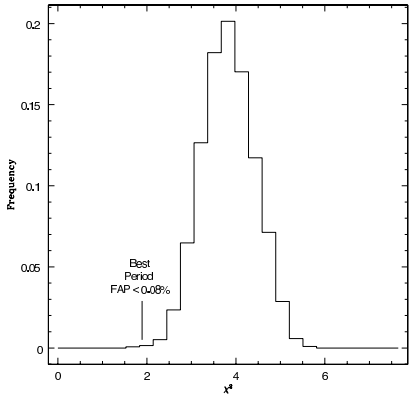

FIGURE 4. For each randomized set of data, we compute the strongest peak. An histogram containing the reduced χ^2 of each peak is then constructed. 10000 randomized samples were used to produce this histogram. Only 8 times, the χ^2 of the *spurious* random peak was lower (better) than our best peak, obtaining a FAP of 0.08%.

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